

AN ANALYTICAL STUDY
of
CHILD LEARNING
by

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AN ANALYTICAL STUDY OF CHILD LEARNING

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In the field of learning, experiments with young children offer most promising opportunities. It is a question whether the so-called rational learning test differs greatly in the principles involved from other types variously called motor skill or formation of associations or solution of problems.

In 1918, Peterson (4) published results from a group of learning experiments about which he says, "A sort of choice-reaction problem is presented to the human subject, about whose rational ability there is no doubt. It is our purpose to see how rational learning is related to learning that must depend wholly on 'trial and error' efforts. How effectively are ideas used in a type of learning in which their employment is obviously helpful?" The experiments in question and results of later investigators who have used Peterson's test will be discussed here as being similar to the learning problems in the present investigation. None of the subjects so far have been young children, the studies have been made with college students, with disabled soldiers, and in comparative studies of negroes and whites. In the Rational Learning Test, as devised by Peterson (4) in 1917, the numbers one to eight inclusive were assigned in random order to the first eight letters of the alphabet. The reactions required of the subject were to associate each of these numbers with the letter assigned to it. This was to be done, according to the author, by means of a series of guesses, the range of which might be greatly limited by the use of a rational organization of the situation. Each subject completed the learning at a single sitting, the learning being completed when the subject had given the whole series twice without error. Record was kept of time, repetitions, and errors. There are three classes of errors: unclassified errors, all responses made except the correct ones; logical errors, numbers which have already been used for earlier letters of the series; and perseverative errors, numbers already guessed wrongly for the letter in question. The test is of such nature as to admit of several forms of different grades of difficulty according to the numbers of letters used.

Various forms of the Rational Learning Tests have been used extensively by Peterson and his students, particularly in a series of studies of the comparative abilities of negroes and whites (5) (6) (7) (8). It is interesting to note that they found the negroes to be relatively stronger in retention than in rational organization when compared with the whites.

Heron (3) conducted a study in which he used five stylus mazes of slightly different patterns and two forms of the Rational Learning Test, a ten-letter and a fifteen-letter form. Results indicated that there was practically no relationship between the learning of the maze and rational learning. Also, there was found a fairly high degree of relationship between the scores in the two Rational Learning Tests.

Haught (2) in an investigation of the interrelation of some learning processes with eighty college students used two forms of the Rational Learning Test, the ten-letter form and one which he called "Rational Learning (Modified)." Apparatus similar to that used in the last named test has been employed in the present investigation of the learning of young children and will be described in detail later. It consisted of a board through which were put bolts arranged in rows. One bolt in each row was connected in an electric circuit so that a bell would ring when the correct bolt was touched by a stylus which was also a part of the electric circuit. Records like those originally devised by Peterson were kept. Correlations and inter-correlations were calculated and it was found that for the Rational Learning Test repetitions and perseverative errors were the significant factors, that is, contained everything that was common to the other factors. For Rational Learning (Modified) time and unclassified errors were the significant factors. Garrison (5) later under somewhat different conditions, with the eight-letter form of the test, found time and logical errors to be the most important and reliable factors, when correlated with intelligence. Both Haught and Garrison found positive correlations between intelligence and the different test factors

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with the exception of perseverative errors, which were not found to be statistically reliable by Garrison.

PROBLEM

The need of further study and analysis of the learning of young children under experimental conditions has prompted this investigation wherein was presented to the child a learning problem, the completion of which depended more on the use of ideas than on the development of a comparatively high degree of motor skill.

The investigation consisted of three experiments in each one of which different groups of children were subjects. In some instances, however, a child who had not completed one experiment was used in a later one.

Subjects.

The subjects in this study were sixty-seven children enrolled in the Child Institute of the Johns Hopkins University with a chronological age range of 2 years 4 months to 5 years 4 months and an Intelligence Quotient range of 96 to 168. The chronological ages were reckoned at the beginning of each learning problem. The Intelligence Quotients were derived from the Stanford Revision of the Binet-Simon tests, which were available for all subjects. These intelligence tests were given as a part of the Child Institute routine and, with five exceptions, had all been given within four months of the time each learning experiment began.

Apparatus and Procedure.

Apparatus which has been built in the Psychology Laboratory of the Johns Hopkins University according to Haught's (2) description of his Rational Learning board was used in all three experiments in this investigation.

This description is given below:

"The apparatus consists of a board about twenty inches square through which are put one hundred bolts arranged in ten rows with ten bolts in a row. The rows are lettered from A to J and the bolts in each row are numbered 1 to 10. One bolt, and only one, in each row is connected in a circuit with an electric bell so that when the bolt is touched with a stylus the bell will ring."

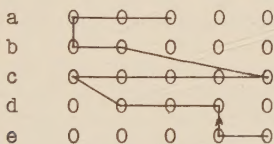
In the diagram of the apparatus that follows each O represents a bolt. The letters A to J and the numbers 1 to 10 were pasted underneath the sides of the board and were not visible to the child during the experiment.

J	O	O	O	O	O	O	O	O	O	O
I	O	O	O	O	O	O	O	O	O	O
H	O	O	O	O	O	O	O	O	O	O
G	O	O	O	O	O	O	O	O	O	O
F	O	O	O	O	O	O	O	O	O	O
E	O	O	O	O	O	O	O	O	O	O
D	O	O	O	O	O	O	O	O	O	O
C	O	O	O	O	O	O	O	O	O	O
B	O	O	O	O	O	O	O	O	O	O
A	O	O	O	O	O	O	O	O	O	O
	1	2	3	4	5	6	7	8	9	10

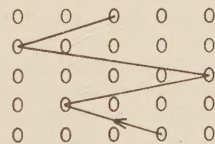
The above description applies to the Learning board used in all three experiments. The whole board was used in the preliminary experiment and on the basis of the results obtained it was decided to use only a part of the board for the

later experiments. The board was too large for the children to reach with ease and also required a longer period for a trial than children of this age will usually attend or cooperate. One-fourth of the board was used for the later series. Thus the learning in experiments II and III was concerned with five rows of bolts, five in a row, one bolt in each row so connected in a circuit with an electric bell that when the bolt was touched with a stylus the bell would ring. The original board was covered with black cloth, with the exception of the lower left quarter of the board. The learning board was firmly attached to a table whose top was slightly tilted in order to make it comfortable for the child to reach all of the bolts easily and to give him the best possible view of the whole top of the board. The stylus with which the bolts were touched was six inches long and was of light weight, the metal core being covered with a handle of hard rubber and the part grasped by the child one-half inch in diameter. This proved to be satisfactory for all subjects with the possible exception of the two-year olds. Fatigue expressed by two of them may have been partly due to this source.

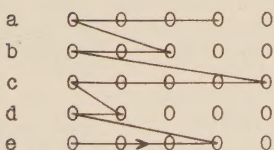
The experiments were all conducted with only the subject and the experimenter present in the room. The procedure in general was the same for all experiments. The child came into the room to play a "game," which soon became known as the "ring the bell game." The child always stood in front of the board with Row A nearest him. The experimenter was seated behind him and slightly to the right. In this way the experimenter had a full view of the subject's performance and could record all responses as made. The child always began a trial with the stylus held in his right hand. Time was kept with a stop watch. Record of each bolt touched by the subject was kept. In the preliminary experiment Peterson's (4) method was followed, the experimenter writing down the number of the particular bolt touched. In Experiments II and III mimeographed record sheets like the diagram of apparatus were used. The experimenter drew a continuous penciled line on the record sheet, which indicated each bolt touched by the subject and the order in which it was touched. Figure 1 gives a replica of the record of the first and last trials of one of the subjects who completed Experiment II and one who completed Experiment III.



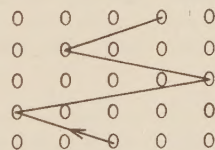
Subject: 23
Trial: 1
Time: 30"
Errors: 10-6-0



Subject: 23
Trial: 60
Time: 9"
Errors: 0-0-0



Subject: 34
Trial: 1
Time: 48"
Errors: 13-7-0



Subject: 34
Trial: 20
Time: 7"
Errors: 0-0-0

Figure 1.

Replicas of records of the first and last trials of subject 23-II and of subject 34-III

EXPERIMENT I

In the preliminary experiment in this investigation the Haught Rational Learning board was employed. The board was arranged for schedule 1: A-6, B-4, C-9, D-1, E-8, F-10, G-3, H-2, I-7, J-5 as described by Peterson (4). This means that when bolt 6 in row A, bolt 4 in row B, etc. were touched with the stylus the bell would ring. When a non-ringing bolt was touched, that is, all bolts except those enumerated above, it constituted an error. In this investigation Peterson's (4) classification of errors was considered as follows: 1. unclassified errors, those errors which consisted in touching any bell that did not ring; 2. logical errors, errors which consisted in touching a bolt that had already been used for an earlier letter in the series; 3. perseverative errors, errors which consisted in repeating a wrong response.

Eight children, 4 years of age, took part in the preliminary experiment. It was decided to use the same instructions in this form of learning as was used with adults. On the basis of the results modification of procedure in later forms was made. The child came into the room with the experimenter to play a "game" and was shown the board covered with a cloth. As the child stood in front of the board the experimenter removed the cloth and said "You see this board. It has ten rows of bolts, ten bolts in each row. One bolt in each row and only one will ring a bell when you touch it with this stylus. (The experimenter showed the stylus which she held in her hand and continued). In each row a different bolt rings. The game is to begin with the bottom row and find the bolt that rings the bell. As soon as the bell rings go up to the next row and find the bolt that rings. Keep on up to the top row and find all the bolts that ring. Remember (pause) begin at the bottom row and as soon as the bell rings find the next bell. The game is to find all the bolts that ring just as quickly as you can." The experimenter laid the stylus down on the board and as the child picked it up said, "Begin with the bottom row. Now, go ahead."

When the trial was completed the experimenter said, "Let's play the game again. Remember, begin with the bottom row and find all the bells. As soon as the bell rings go up to the next row." Three trials were given in one sitting.

A sitting of four repetitions was tried out with the first subject taken, a boy who was most cooperative. He required 455 seconds to complete the sitting, the time of the repetitions being 105, 112, 98 and 140 seconds respectively. This was too long a sitting for children of the ages under consideration so it was decided to have each sitting consist of three repetitions. A total of 121 repetitions was secured from the eight subjects before the close of the school session which terminated this preliminary experiment.

In table 1 the total number of repetitions, total time and total errors for each subject are given. As this was undertaken as a preliminary experiment, the subjects were given opportunity to continue the problem until the close of the school term. Absences account for the irregular number of repetitions for each subject.

A study of the results obtained from this exploratory experiment revealed certain trends which seemed suggestive despite the extreme difficulty of the board and the small number of children concerned. A decrease in average time and errors was noted when the averages of the earlier trials were compared with the averages of the later trials. (See figures 2 and 3). Certain bolts were learned more quickly as to their position on the board. The first and last bolts in a row, D-1 and F-10, were found without error the greatest number of times. (See figure 4). The ringing bolts in the bottom and top rows, A-6 and J-5, came next in the order of times found. The tendency of some of these children to begin each row at the extreme right or the extreme left of the board may somewhat explain the greater number of successes for D-1 and F-10. Three of the children began with the first bolt in a row more than 50% of the time and two began with the last

bolt in a row over 50% of the time. Individual differences were marked for amount of time required per trial and for the number of perseverative responses. For total number of errors and for logical errors the individual variations were small. There were wide variations from day to day for individual children.

TABLE 1

Scores for individual subjects in rational learning.

CA chronological age in years and months at beginning of experiment; IQ Stanford-Binet Intelligence Quotient; UC unclassified errors; (L) logical errors; (P) perseverative errors; DNC "did not complete."

Subject	CA	IQ	Sittings	Trials	Time	Errors			
						UC	L	P	
1	3-11	104	3	10	1391	496	256	54	DNC
2	3-11	108	1	3	453	146	76	16	DNC
3	4-4	115	5	15	1451	673	329	10	DNC
4	4-5	128	5	15	2011	730	359	29	DNC
5	5-0	129	7	21	2347	963	528	21	DNC
6	5-3	101	8	24	2757	966	521	31	DNC
7	5-3	133	8	24	4331	1113	518	138	DNC
8	5-4	137	3	9	807	387	194	6	DNC
Total			40	121	15548	5474	2781	325	
Average per trial					128.45	45.45	22.9	2.7	

EXPERIMENT II

The inadequacy of the entire Haught Board for the study of learning of children as young as this group led to use of only a portion of the original board in the second and third series. One-fourth of the Haught Board gave a pattern of five ringing bolts from a total of twenty-five instead of a pattern of ten ringing bolts from a total of one hundred. This proved to be a difficult enough pattern for children of these ages.

Twenty-four children between three years and five years, four months old took part in the experiment. The method used was a three minute work limit with an interval of one week between sittings. All children were allowed to complete the trial in process when the three minute working time was up but no new trial was begun within five seconds of the end of the three minutes. Two somewhat different methods of attack were used in this work limit experiment, which will be described as Form A and Form B. The schedule of ringing bolts for both Forms A and B was the same as illustrated in figure 4. No ringing bolt was directly over or under the ringing one in the adjoining row nor was it adjacent to the ringing one.

The board was mounted as in the preliminary experiment. The child and the experimenter were also in the same relative positions. The child stood in front of the board with the experimenter seated behind him and slightly to the right with stop watch and stenciled record blank out of the range of vision of the child.

At the first sitting the following directions were given to each of the eighteen children in Form A. "You see this board. Here are some rows of bolts the same number in a row. (The experimenter ran her hand along the five rows). One bolt in each row rings a bell when you touch it with this stylus. (Here the experimenter showed the stylus which she held and touched the ringing bolt in the third row). Only one bolt in each row will ring. The game is to begin with the bottom row and find the bolt that rings the bell. As soon as the bell rings, go up

to the next row and find the bolt that rings. Keep on up to the top row finding the bolt in each row that rings. I want you to learn so that you will touch only the bolt that rings. Begin with the bottom row here. (Pointing toward bottom of board.) Now, go ahead."

If the child hesitated too long at any time he was urged to go on. When one trial was completed the experimenter said: "Now, let's play the game again. Ready, go."

At the second sitting one week later the directions to the child were shortened. When he was standing in front of the board and the cover had been removed the experimenter put the stylus in the child's hand holding it as she said, "You know what you did before, you began with the bottom row and touched the bolt in each row that rings. Remember you want to learn so you will touch only the bolt that rings. Ready, Go." As before if the child hesitated too long or stopped he was told to, "Go on and find the bell." When one trial was completed he was again told, "Now let's play the game again. Ready, Go," until three minutes' time was up.

Form B. In the course of the experiment it seemed to be of interest to know how children might attack a problem of this kind when left more to their own devices. A few children were tried in learning Form B which was similar to Form A except that the children were allowed to begin to touch the bolts on any row. They were told that, "only some of the bolts ring" instead of being told that only one in each row would ring.

Table 2 gives the total scores for trials, time in seconds, and classified errors for each child. The general intelligence of the children as shown by the Stanford Revision of the Binet-Simon Scale was distinctly above normal with the exception of a few cases. A total of 591 separate repetitions was made by the 18 children. The average time for the group for the 591 repetitions was 26.5 seconds, the average number of errors was 8.7.

Table 3 gives the distribution of errors for each subject for Forms A and B arranged according to the row in which they occurred. The fewest number of unclassified errors occurred in Row d where the first bolt was the ringing one while the greatest number of unclassified errors occurred in Row c where the fifth or last bolt was the ringing one. This bolt was the one demonstrated by the experimenter. The rows ranked according to the smaller number of unclassified errors were d with 1143 errors, a with 1243 errors, e with 1289 errors, b with 1481 errors and c with 1768 errors.

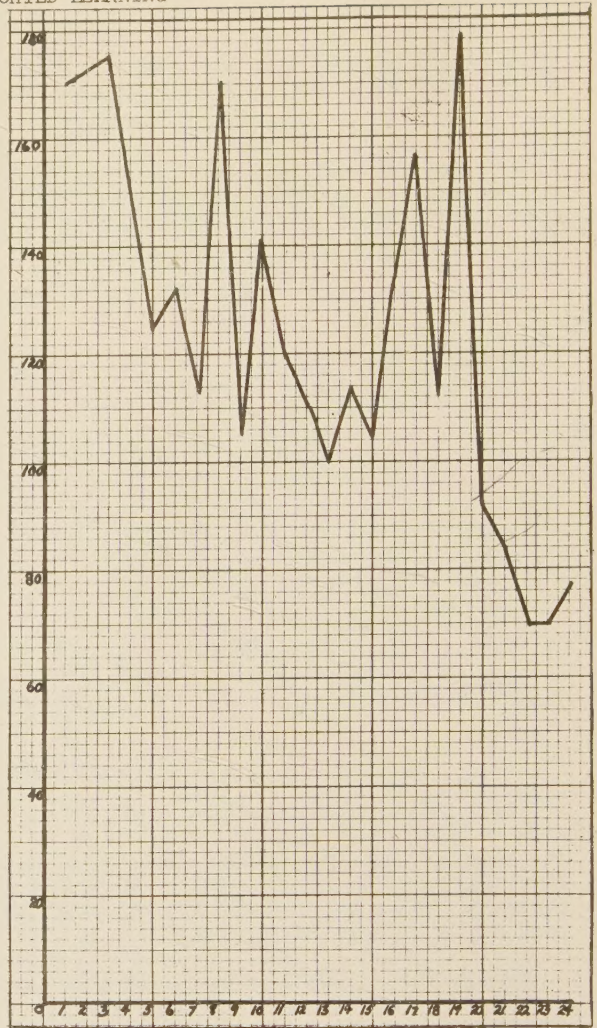


Figure 2

Mean time required by the group for each trial

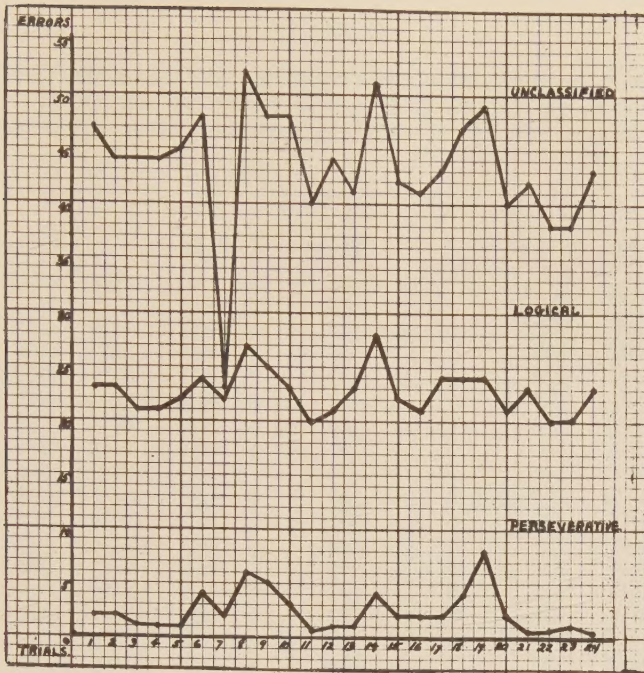


Figure 3
Mean score for errors made by group on each trial

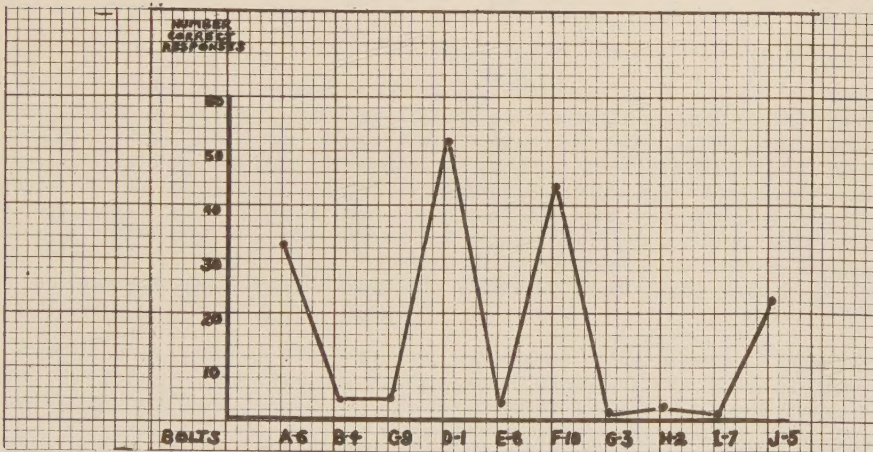


Figure 4
The total number of correct responses by all eight subjects in Experiment I, for the ringing bolt in the respective rows.

TABLE 2

Distribution of repetitions, time in seconds and classified errors in Learning II A and B. CA chronological age in years and months; IQ intelligence Quotient; UC unclassified errors; (L) logical errors; (P) perseverative errors; DNC did not complete.

II FORM A								
Subject	CA	IQ	Sit- tings	Trials	Time	Errors		
						UC	L	P
1	3-0	127	3	9	555	112	68	6 DNC
2	3-2	121	5	14	884	227	109	11 DNC
3	3-5	116	6	28	1086	313	138	25 DNC
4	3-5	130	3	13	540	200	109	9 DNC
5	3-6	135	4	25	724	209	102	14 DNC
6	3-6	120	7	53	1264	514	269	36 DNC
7	3-8	141	6	34	1100	344	205	0 DNC
8	3-11	116	6	49	1081	328	126	7 DNC
9	4-0	149	6	53	1122	275	156	13
10	4-2	113	3	9	558	106	53	11 DNC
11	4-6	132	6	60	1080	325	136	7
12	4-8	135	3	21	518	145	67	1
13	4-9	133	4	27	632	260	108	6
14	4-10	115	2	3	366	40	21	5 DNC
15	4-11	133	3	24	547	187	76	8 DNC
16	4-10	104	5	56	844	411	239	8
17	4-11	104	9	50	1334	441	252	7 DNC
18	5-2	115	8	63	1440	697	276	45 DNC
Total			89	591	15676	5134	2508	219
Average					26.5	8.7	3.5	.4
FORM B								
19	3-7	116	4	7	719	148	73	59 DNC
20	3-10	105	5	25	896	643	349	178 DNC
21	4-4	117	2	2	360	63	30	29 DNC
22	4-4	132	5	15	836	93	47	31
23	4-11	115	2	9	363	132	57	32 DNC
24	5-4	111	5	41	906	711	330	83 DNC
Total			23	99	4080	1790	886	412
Average					41.2	18.1	7.9	4.2

The number of times the ringing bolts were found without errors is given in table 4. d-1 again has the first rank with a score of 372. The other bolts in order of time found are respectively c-5, a-4, e-3 and b-2. The number of errors within a single row is determined in part by the order of striking the bolts. Since the children varied widely in methods of finding the ringing bolt these individual differences explain in great part the frequency of errors for particular rows of bolts. It is clear for this group that the first and last bolts in a row are found without error, that is, they are learned more quickly than other bolts.

TABLE 3

Distribution of classified errors for each subject for each row in Learning II, Forms A and B

ROWS

Sub- ject	Trials	a			b			c			d			e		
		UC	L	P	UC	L	P	UC	L	P	UC	L	P	UC	L	P
1	9	10	0	1	21	8	1	32	20	2	31	22	1	18	18	1
2	14	43	0	0	54	13	5	44	22	4	45	33	1	41	41	1
3	28	73	0	1	50	10	6	114	57	17	19	14	0	57	57	1
4	13	37	0	0	38	11	1	29	16	2	56	42	4	40	40	2
5	25	25	0	0	57	18	7	80	42	6	19	14	0	28	28	1
6	53	76	0	7	72	12	4	203	105	16	56	43	6	107	107	3
7	7	22	0	6	30	3	11	37	19	15	25	19	12	34	34	15
8	34	35	0	0	104	34	0	1	1	0	136	102	0	68	68	0
9	25	100	0	15	117	29	28	142	70	46	147	113	48	137	137	41
10	49	85	0	2	64	10	3	119	58	0	7	5	0	53	53	2
11	53	10	0	0	114	41	7	62	33	2	34	27	2	55	55	2
12	9	18	0	1	24	7	5	19	9	1	25	17	2	20	20	2
13	2	13	0	6	6	1	2	16	5	2	14	10	7	14	14	6
14	15	17	0	6	20	3	5	16	6	5	15	14	5	25	25	10
15	60	55	0	0	82	20	2	121	59	5	30	20	0	37	37	0
16	21	27	0	0	29	3	1	35	12	0	8	6	0	46	46	0
17	27	76	0	3	25	1	0	99	49	3	10	8	0	50	50	0
18	3	7	0	0	9	3	2	10	5	2	7	6	1	7	7	0
19	24	40	0	3	40	8	2	73	39	0	16	11	3	18	18	0
20	56	40	0	0	132	42	0	13	7	0	144	108	4	82	82	4
21	9	33	0	8	28	6	6	30	14	8	19	15	4	22	22	6
22	50	52	0	2	123	39	3	32	17	2	152	114	0	82	82	0
23	63	195	0	10	101	12	18	264	131	13	14	10	2	123	123	2
24	41	154	0	19	141	32	27	177	88	13	114	85	17	125	125	7
Total	690	1243	0	90	1481	366	146	1768	884	164	1143	858	119	1289	1289	106

Table 2 gives a distribution of the six children who worked by the trial and error method of approach, Form B. A study of the table will show for the six children a total score of 4080 seconds in time, of 1790 unclassified errors, of 886 logical errors and 412 perseverative errors. The corresponding average scores for the group based on the 99 repetitions made were respectively 41.2 seconds, 18.1 unclassified errors, 7.9 logical errors and 4.2 perseverative errors. In comparison with the scores for Form A the time per repetition for this group was one and a half times as long; there were twice as many unclassified and logical errors in a repetition and more than eight times as many perseverative errors.

However in a group as small as this individual differences may largely account for this seeming difference. The larger average times taken is partly accounted for in that a repetition was not completed until all the ringing bolts were found and sometimes a child would keep touching the ringing bolts found without trying to find all of them. One of the six, subject 22, a four year old boy, completed the learning. His record is included with the five completing Form A.

The reductions in time for successive repetitions for all children in II Forms A and B are clearly shown by the average scores for each repetition which are given in table 5. The average time for the first repetition was 76.4 seconds; for the 60th trial 19.5 seconds. The reduction in errors with successive trials are also given in this table. The variability in decrease is to be explained by the dropping out of those children who completed the learning. Figure 5 shows these same reductions at intervals of ten repetitions.

TABLE 4

Distribution of number of correct responses for each subject in each row Forms A and B. a-6, etc. refer to the letter of row on board and position in row of ringing bolts.

Subject	Trials	Number of correct responses					Total	Per cent correct
		a-4	b-2	c-5	d-1	e-3		
1	9	2	0	0	0	0	2	4.4
2	14	0	1	1	2	0	4	5.7
3	28	2	0	3	23	0	28	20.0
4	13	0	1	4	0	0	5	.7
5	25	14	2	3	13	7	39	31.2
6	53	19	10	5	36	2	72	27.1
7	7	0	0	0	0	0	0	0
8	34	0	0	33	0	0	33	19.4
9	25	0	0	0	0	0	0	0
10	49	17	11	11	46	25	110	44.9
11	53	43	9	26	41	24	143	53.5
12	9	2	1	1	0	1	5	11.1
13	2	0	0	0	0	0	0	0
14	15	11	5	8	9	8	41	54.6
15	60	37	11	26	46	40	160	53.3
16	21	10	4	4	19	6	43	40.9
17	27	3	3	3	8	3	20	14.8
18	3	0	0	1	0	1	2	13.3
19	24	5	3	0	19	12	39	32.5
20	56	20	7	51	21	17	116	41.4
21	9	1	3	1	5	2	12	26.7
22	50	6	6	39	9	8	68	27.2
23	63	1	0	0	59	3	63	70.0
24	41	0	0	0	16	0	16	7.8
Total	690	193	77	220	372	159	1021	

In figure 6 the learning scores for time and unclassified errors of the six children who completed the learning, five in Form A and one in Form B are shown. A downward curve again appears for both time and errors, with the error score also showing an irregularity between the 30th and 40th repetitions. This irregularity may be partially explained by the effect of individual differences in so small a number of subjects.

Figures 7 and 8 show individual learning curves of two of the subjects who successfully completed the learning. Both show a rapid decrease of both time and errors in the later repetitions.

Summary. Learning as shown by the decrease in time and errors was shown by all children taken individually, both by those who completed the learning successfully and also by those who did not quite complete it within the limits of the experiment.

TABLE 5

Distribution of averages of time in seconds and classified errors for each repetition in II, Forms A and B.

Trials	Time	Errors		
		UC	L	P
1	76.4	17.2	9.7	4.0
2	55.9	13.9	7.2	2.0
3	50.7	15.3	7.6	2.1
4	46.4	14.4	7.0	1.7
5	34.7	12.8	6.5	1.2
6	33.4	11.4	5.9	.7
7	37.7	12.2	6.2	.7
8	36.4	10.2	5.4	1.0
9	29.4	10.7	5.2	1.2
10	28.8	10.5	4.9	.8
11	30.0	10.8	5.6	1.1
12	26.8	10.5	5.1	.3
13	29.7	11.4	5.6	.3
14	26.8	10.6	5.5	.2
15	21.7	8.7	4.4	.2
16	28.4	9.7	4.5	.9
17	26.0	10.8	5.4	1.6
18	23.5	8.8	4.1	.6
19	24.7	10.6	5.5	2.3
20	26.5	9.4	4.7	.3
21	25.7	8.1	4.1	.1
22	27.0	12.1	5.4	1.8
23	22.4	9.6	4.6	.3
24	22.6	9.9	5.0	.5
25	18.5	10.4	4.9	.9
26	18.4	8.4	3.9	.3
27	20.7	9.3	4.4	.5
28	22.6	9.7	4.7	.5
29	19.4	7.6	4.2	.1
30	20.4	9.6	4.7	.4
31	19.6	10.5	5.3	1.3
32	17.4	8.6	4.1	.1
33	23.3	8.0	3.9	0
34	19.0	8.4	4.1	0
35	15.4	7.5	4.1	.1
36	18.3	9.1	4.1	.8
37	20.1	9.4	4.8	.8
38	18.5	7.9	4.0	.6
39	20.6	8.6	4.0	1.3
40	19.9	7.6	3.5	0
41	17.6	7.5	3.5	.1
42	20.1	5.7	2.9	.2
43	16.0	6.7	2.9	.3
44	16.6	4.7	2.4	0
45	22.9	5.7	2.4	.5
46	15.3	4.4	1.9	1.0
47	14.7	3.3	1.4	0
48	15.7	3.5	1.4	0
49	20.0	4.9	2.4	0
50	15.8	4.3	1.7	0
51	17.6	4.4	1.8	0
52	15.2	4.0	1.6	0
53	16.4	4.6	1.8	.2
54	12.7	3.3	1.3	0
55	14.3	3.6	1.3	0
56	12.7	4.3	1.3	1.0
57	15.0	5.5	2.5	0
58	18.5	7.0	3.5	0
59	23.0	6.0	2.0	1.0
60	19.5	4.5	1.5	0
61	22.0	7.0	1.0	0
62	15.0	8.0	2.0	0
63	40.0	10.0	3.0	0

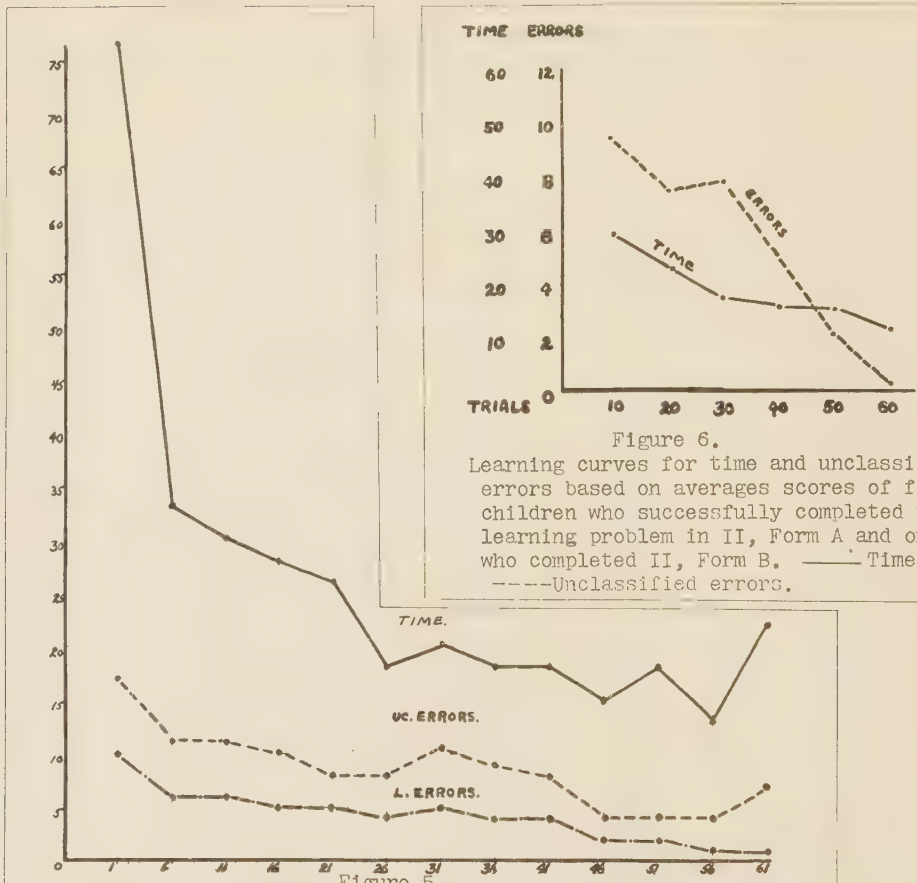


Figure 5.

Learning curves for time and errors based on group averages for II, Form A and B. —Time.

---Unclassified errors. —Logical errors.

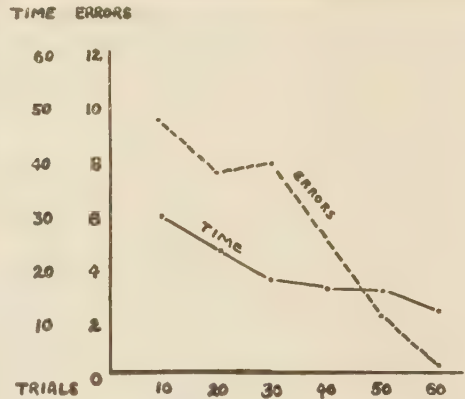


Figure 6.

Learning curves for time and unclassified errors based on averages scores of five children who successfully completed the learning problem in II, Form A and one who completed II, Form B. —Time. ---Unclassified errors.

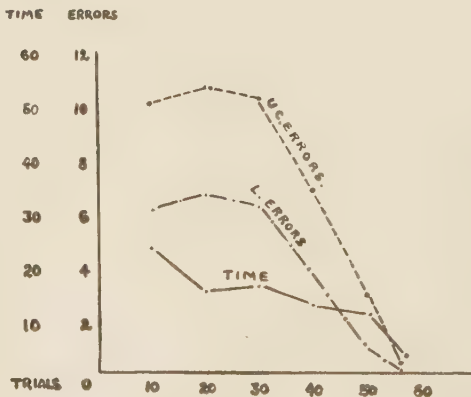


Figure 7.

Learning curve for time and errors of subject 16 who completed II, Form A.

—Time. ---Unclassified errors.

---Logical errors.

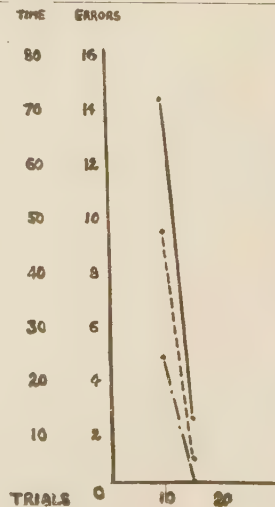


Figure 8.

Learning curve for time and errors of subject 22 who completed II, Form B.

EXPERIMENT III

The third and last experiment in this investigation differed in that a work limit rather than time limit was employed for each sitting. Otherwise the procedure was similar to that in I and II with the exception of a modification of the instructions. This group consisted of thirty-five children, twenty boys and fifteen girls, whose ages ranged from 2 years, 4 months, to 5 years, 2 months. The problem was new to all but five of the children.

Five trials were made in one sitting and the sittings occurred twice a week. A different schedule of ringing bolts was arranged so that bolts a-3, b-1, c-5, d-2 and e-4 made the pattern to be learned. These were the third bolt in Row A, the first bolt in Row B, the fifth bolt in Row C, the second bolt in Row D and the fourth bolt in Row E.

Directions to the child were further defined and the procedure was as follows: At the first trial the board was shown to the child as he stood in front of it with the 25 bolts exposed, then the experimenter began: "See these buttons. Some will make a bell ring when you touch them with this rod." The experimenter covered with cardboard all except the top row then said: "Watch me find the button that rings in this row," (beginning at the left and touching each button with the stylus until the fourth bell rang). "Here it is. This is the only one to ring in this row. If I touch the others they will not ring. See." As she touched the remaining one in that row she said: "Only one in this row rings, now you find it." The stylus was put in the child's hand and if he made a move to begin at the right he was told: "Wait, begin over here." If he moved to continue after finding the bell, the experimenter said: "Stop now. Only one bell in each row rings. Let's try another row." This time all rows except the middle one was covered and the child was told: "Find the bell that rings in this row." The same procedure was followed in having the child begin at the left and stop when he found the bell. The cardboard was then removed and pointing to the bottom row at the left the experimenter said: "Begin here and find the bell in each row that rings." No more instructions were given, except to say "Go and find the bell," if the child stopped, or to show him the next row, if he tended to go elsewhere. This was done only on the first trial. Record of the performance of the child was kept as in the preceding experiments.

The totals for repetitions, time and errors of the 35 children who took part in this third experiment are given in table 6. Here will also be seen the chronological age distribution and the intelligence quotients as found by the Stanford Revision of the Binet-Simon Scale. In this group three two-year-olds were available for trials at the problem and a larger number of three-year-olds for more trials than it was possible to obtain in the second experiment.

In table 7 is shown the distribution of errors for each subject according to rows. The bolts ranked according to fewness of errors are a-3, b-1, e-4, d-2, and c-5. Row c where the fifth and last bolt was the ringing one occupied the same rank as in the second experiment, while the middle bolt in the bottom row occupied the first rank. When the order of the ringing bolts is taken from table 8, they become in the order of times found respectively b-1, a-3, e-4, c-5, and d-2. Thus the first bolt in a row was found the greatest number of times and the second bolt in a row the fewest number of times whether this latter bolt was in Row b or in Row d as occurred in the two schedules used.

Individual Variations. Five of the children in this group had taken part in the second experiment one year before when they were three years old as indicated in table by r. In this third experiment three learned the problem successfully but two were unable to complete the problem. The younger children varied more widely as to method of procedure and tended to touch the bolts in columns as well as in rows.

TABLE 6

Distribution of subjects in Experiment III as to chronological age; intelligence quotient, trials, time in seconds and classified errors. (r) -- These children took part in II. DNC--did not complete.

Subject	CA	IQ	Sit- tings	Trials	Time	Errors			
						UC	L	P	
1	2-4	131	8	30	2303	353	188	37	DNC
2	2-7	131	4	15	1238	178	83	22	DNC
3	2-8	168	17	85	3155	880	436	58	DNC
4	3-0	137	12	60	1974	767	440	28	DNC
5	3-4	130	7	35	899	367	216	9	DNC
6	3-7	114	4	13	1052	159	76	18	DNC
7	3-7	128	17	85	2832	989	428	50	DNC
8	3-8	97	9	45	1631	470	269	15	DNC
9	3-9	111	15	80	2185	741	366	41	DNC
10	3-10	100	11	55	1726	572	251	8	DNC
11	4-0	158	8	40	844	388	232	11	DNC
12	r 4-0	127	12	63	1070	334	147	15	
13	4-0	133	20	100	2911	1051	545	68	DNC
14	4-1	126	7	36	791	178	100	3	
15	4-2	96	6	30	1550	303	127	24	DNC
16	4-2	125	13	66	1348	438	264	5	
17	4-2	129	10	49	1335	393	231	2	
18	r 4-3	142	5	26	484	110	58	2	
19	4-3	120	9	45	1365	447	269	24	DNC
20	4-4	130	8	40	929	347	232	4	DNC
21	4-4	113	1	45	1227	390	223	23	DNC
22	4-4	100	10	50	1385	430	290	14	DNC
23	4-4	138	6	30	1028	350	174	62	
24	r 4-5	111	8	38	621	244	127	8	
25	4-5	110	13	64	1234	485	295	9	
26	4-5	100	20	100	2078	648	297	8	
27	r 4-6	121	7	35	814	294	203	2	DNC
28	4-6	113	16	79	1444	491	342	15	
29	4-7	137	13	65	1106	408	160	15	
30	r 4-9	105	15	75	1906	558	332	25	DNC
31	4-9	115	6	28	575	104	59	8	
32	4-10	100	7	36	910	308	145	3	
33	4-11	116	8	41	682	200	98	8	
34	4-11	87	4	20	347	111	62	2	
35	5-2	113	3	15	291	142	93	1	DNC
Total			339	1719	47270	14628	7858	647	
Average					27.5	8.5	4.5	.4	

Reduction in time with successive repetitions for all children in this experiment is also shown by the averages as illustrated in figure 9. The average time for the group for the first repetition was 50.0 seconds and for the 100th repetition was 21.0 seconds. Reductions in errors also were found for unclassified, logical and perseverative errors respectively of 11.4 to 8.0, of 6.3 to 2.0 and of 0.7 to 0. Figure 10 shows curves of reductions in time and errors at intervals of ten repetitions for those completing the problem. The rise in the curve after the 80th trial may be largely explained by the dropping out of subjects requiring the fewer number of repetitions for completion of the problem and the small number of subjects remaining. None of the two and three year old children completely learned the problem.

TABLE 7

Distribution of classified errors for each subject for each row in Experiment III. UC - unclassified; L - logical; and P - perseverative.

Sub- ject	Trials	a			b			c			d			e		
		UC	L	P	UC	L	P	UC	L	P	UC	L	P	UC	L	P
1	30	45	0	3	87	27	13	90	44	10	60	43	6	74	74	5
2	15	32	0	5	41	11	6	45	19	8	30	23	3	30	30	0
3	85	137	0	4	213	67	25	175	95	3	235	154	20	120	120	6
4	60	88	0	2	125	50	6	218	111	13	172	115	2	164	164	5
5	35	64	0	0	14	3	2	143	71	6	42	38	0	104	104	1
6	13	21	0	1	52	16	7	28	13	5	39	28	4	19	19	1
7	85	177	0	3	348	91	29	80	35	9	265	183	2	119	119	7
8	45	93	0	3	25	6	7	168	85	2	60	54	3	124	124	0
9	80	140	0	5	116	34	14	222	106	2	156	119	13	107	107	7
10	55	103	0	0	205	55	4	31	15	0	159	107	1	74	74	3
11	40	74	0	1	26	8	3	107	58	0	72	57	7	109	109	0
12	63	20	0	0	109	20	4	155	79	8	23	21	3	27	27	0
13	100	175	0	5	163	47	25	341	169	23	179	136	11	193	193	4
14	36	23	0	0	12	3	1	63	29	1	46	34	1	34	34	0
15	30	57	0	1	70	22	5	87	41	10	78	53	8	11	11	0
16	66	106	0	0	5	1	0	120	65	4	74	65	1	133	133	0
17	49	64	0	0	25	6	0	150	74	1	49	46	1	105	105	0
18	26	5	0	0	39	9	2	4	2	2	45	30	0	17	17	0
19	45	75	0	1	12	3	1	161	80	8	73	60	12	126	126	2
20	40	26	0	0	21	6	2	144	72	2	43	41	0	113	113	0
21	45	36	0	1	79	21	10	93	45	4	96	71	6	86	86	2
22	50	48	0	2	34	12	6	136	72	0	74	68	5	138	138	1
23	30	68	0	5	68	15	15	70	34	14	74	55	16	70	70	12
24	38	38	0	0	6	2	0	121	53	6	43	36	2	36	36	0
25	64	81	0	1	16	6	0	179	89	2	79	70	6	130	130	0
26	100	71	0	1	229	61	6	86	44	1	238	168	0	24	24	0
27	35	6	0	0	22	5	1	132	65	1	38	37	0	96	96	0
28	79	15	0	0	2	0	0	227	110	12	108	93	2	139	139	1
29	65	100	0	0	74	21	5	170	84	9	45	36	1	19	19	0
30	75	31	0	0	40	10	8	305	149	15	88	88	2	94	94	0
31	28	12	0	0	25	8	2	20	9	3	23	18	1	24	24	2
32	36	50	0	0	92	23	0	24	11	0	92	61	1	50	50	2
33	41	53	0	1	5	1	0	83	42	6	30	26	1	29	29	0
34	20	26	0	1	11	2	1	22	11	0	20	17	0	32	32	0
35	15	15	0	0	3	2	0	59	28	1	30	18	0	45	45	0

Total 2175 0 46 2414 674 210 4259 2129 191 2978 2269 141 2815 2815 61

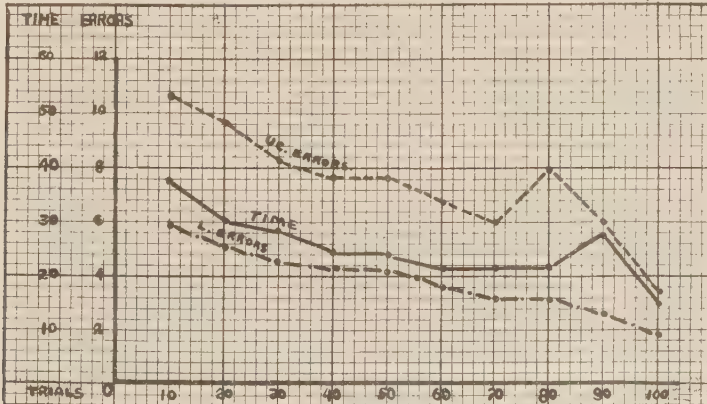


Figure 9.
Learning curves for time and errors based on
average scores for Form III.

TABLE 8

Distribution of correct responses for each subject for each row in Experiment III.

Subject	Trials	Correct responses for each row					
		a-3	b-1	c-5	d-2	e-4	Total
1	30	7	2	2	0	1	12
2	15	2	2	1	1	1	7
3	85	15	10	8	5	32	70
4	60	16	3	4	1	1	25
5	35	3	29	0	1	0	33
6	13	1	0	3	1	6	11
7	85	5	1	56	0	2	64
8	45	1	38	0	3	0	42
9	80	13	48	12	3	40	116
10	55	3	4	45	1	0	53
11	40	2	30	7	1	1	41
12	63	53	18	9	47	53	180
13	100	19	50	6	14	31	120
14	36	23	13	17	9	19	81
15	30	4	6	4	1	21	36
16	66	7	64	30	10	20	131
17	49	18	35	7	8	11	79
18	26	23	15	23	6	12	79
19	45	7	41	1	2	1	52
20	40	27	34	4	2	0	67
21	45	25	25	17	1	2	70
22	50	26	39	6	3	0	74
23	30	6	10	9	10	10	45
24	38	12	33	3	10	19	77
25	64	24	56	15	9	19	123
26	100	63	35	61	12	79	250
27	35	32	26	0	0	3	61
28	79	70	77	22	6	28	203
29	65	15	40	15	37	53	160
30	75	58	61	1	6	39	165
31	28	22	19	22	12	18	93
32	36	11	9	29	4	3	56
33	41	12	32	14	21	27	106
34	20	7	16	13	7	8	51
35	15	6	13	0	0	0	19
Total	1719	638	934	466	254	560	4571

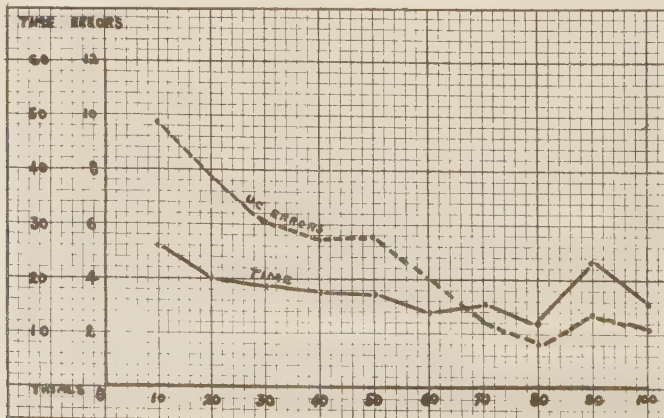


Figure 10.
Learning curves for time and unclassified errors
based on average scores of 15 children who
successfully completed Form III.

Fifteen four year old children from this group successfully completed the learning in this experiment to the extent of three successive errorless repetitions. Only one child required more than 80 repetitions. He completed the problem in 100 repetitions.

Individual learning curves of four children are given in figures 11 and 12. All show a decided reduction in time and errors, as well as differences in repetitions required. The rise at the 40th trial in the curve of subject 16-III may be explained by a prolonged absence of 77 days.

Ten of the fifteen children who learned the problem in Form III relearned it, one after a period of two months and nine after a period of one week. In every instance there was a decided decrease in repetitions and in time and error scores. Further evidence of a rational approach to the problem was given in that only one perseverative error occurred in all the 93 repetitions made by the ten children. Logical errors were next in rate of decrease. Three of the ten children made no logical error and two made only one each.

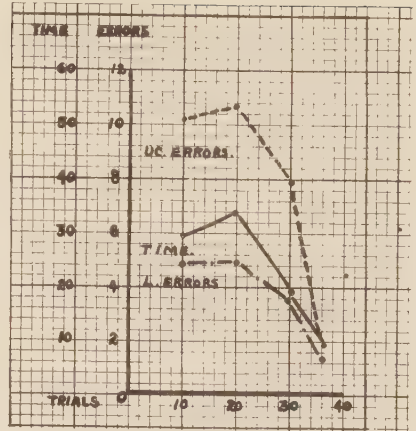


Figure 11. Learning curves for time and errors of subject 32-III

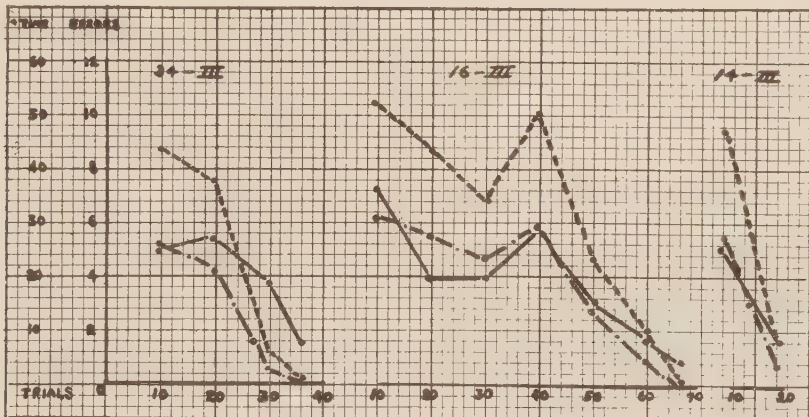


Figure 12.

Learning curves for time and errors of subject 34-III, 16-III, and 14-III. — Time. ---- Unclassified errors
 Logical errors.

Individual differences continued to have decided influence in this somewhat larger group of children in the third experiment. Results on the whole further strengthened the findings of the earlier experiment in relation to decrease in errors and in time required as the learning progressed. Particularly do the decreasing logical and perseverative error scores in the relearning seem to give further evidence of the ability of these children to use a rational organization of material such as this in the solution of a problem.

Comparative Analysis of the Three Forms

It has been shown by investigators that adults presented with a problem whose solution requires an elimination of errors are able to facilitate the solution by a so-called rational organization of material rather than by a trial and error method.

In this investigation it has been demonstrated that young children from two years, 4 months, to 5 years, 4 months, of age gave responses similar to those of adults. They require a longer time for learning and there has been more of the element of trial and error than in the case of adults. With learning distributed over a long period these young children have succeeded in arriving at the point where, through a voluntary choice shown by not touching bolts touched earlier in the experiment, errors have been reduced from the number made when each bolt was touched to the point where none was made and the criterion of three successive errorless repetitions was met.

Grouping errors under the three classifications of unclassified, logical and perseverative errors, it was found that in the early stages of the problem all three classes occurred. The number was determined largely by the child's method of beginning at the edge of the board or at some other point and proceeding in regular order to touch all bolts until he encountered the ringing one. As the learning progressed choices were made, the child not touching bolts that had already been found in that place in other rows and not logically correct.

All three classes of errors persisted to a certain degree even into the later stages but the data show a decrease with practice.

With the larger Haught Board the time required for learning such a complicated pattern and the difficulty of a mechanical nature occasioned by the necessity of such young children having to reach a long distance to touch the bolts in the top row made completion of learning inadvisable for them. They persisted in the problem to such an extent that even in the 24 repetitions a reduction of errors did occur.

With the smaller board of 5 ringing bolts three methods of procedure were followed. Eighteen children working for three minutes at a time attempted to learn the pattern by beginning at a certain place on the board, the bottom row, and proceeding by rows to the top row. Six working three minutes at a time were allowed to begin touching bolts at any point on the board and proceed in any way they wished. A third group of 35 children began at the extreme left in the bottom row and proceeded by rows to the top row. Variations in methods of procedure showed an advantage with regard to elimination of errors for the work limit of 5 trials a sitting over the time limit of 3 minutes of practice in one sitting.

The greatest number of errors was made with the trial and error form when the child was free to find the bells in any way he chose. Within the limits of the experiment only one child successfully completed the learning by the trial and error method of procedure. However, he attacked the problem vigorously and reached the criterion of success in an exceptionally small number of repetitions. Comparing the work limit of 5 trials at a sitting with the time limit of 3 minutes of practice, the latter has a slight advantage as regards the number of trials made by those successfully completing the experiment.

Of the twenty-one children from all groups who learned the problem to the extent of making three errorless repetitions 10 relearned it after an interval of one week according to the same criterion of success. Nine of these children made no perseverative errors. The total score for these ten was one perseverative error. Three of them made no logical error while the individual scores of all were reduced in every instance. Two children relearned the problem after an interval of two months. Their perseverative error scores were practically the same, while

their logical error scores were very greatly reduced.

SUMMARY AND CONCLUSIONS

In this study of a learning problem that permitted selection of response by the child and a rational method of solution sixty-seven children were tested. There were 42 boys and 25 girls. Three forms of procedure were used though the problem remained essentially the same.

The actual time required for such a problem does not appear to be as significant a measure as the number of errors. The time is a function of the method of attack upon the problem and the wide differences among individuals as to methods employed at various stages of learning would invalidate direct comparisons.

The errors have been grouped as logical, perseverative or unclassified. In the initial stages of learning the logical and perseverative errors are frequent but they decrease more rapidly than the unclassified errors do. The total number of errors made appears to be the best criterion of learning. The elimination of logical errors does show the ability of children as young as three years to use the method of learning termed rational for adults.

Learning appeared to be facilitated in part by the position of the ringing bolt on the board. There was a tendency for the first bolt in a row to be found more frequently without error and also for the correct bolt in the first row and in the last row to be learned earlier than those in the intermediate rows.

Ability to complete the problem and to make a rapid improvement in elimination of errors increases with age. No two-year-old child succeeded in making a final correct response within the limits of the experiment but almost attained success. The closing of the school interfered with their achieving the stage of efficiency set as a criterion. Children who were exactly 4 years of age at the beginning of the experiment did succeed. The number of repetitions necessary for solution decreased with the age of the child with some exceptions. It does appear that a child who shows greater ability in other performances such as give higher intelligence quotients also makes more rapid improvement in this form of learning.

Wide individual differences in performance occurred as measured by the time taken and by the number of errors occurring. This was noted for all children, for those successfully learning the problem and for those partially completing it. Study of the individual records of children in this form of learning shows that the trial and error method of the initial stages is replaced by a rational organization of material.

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Vita.

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